Design & Construction of Arduino Based Energy Meter



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Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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Certification

This is to certify that this project entitled "**Design & construction of Arduino Based Energy Meter**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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ABSTRACT

Microcontroller platform Arduino Based Integration of Energy Meter is very effecient & workable project. In this project we developed a energy meter which can sensing load current ,voltage & calculate the KWH & Bill.It is very suitable for industry or home. This project produces the design and building a system that gives a solution to the measurement of energy and helps the local customers to save the power in an efficient manner. Also, in this project we used a Arduino as a brain of our project & we used a voltage sensor ,current sensor for measuring the voltage & corrent of laod.The system consists of power consumption energy meter at customer homes.we have also used a lcd display So that the customer can see the load voltage ,current ,& he can see his bill.Total project is a complete soultion of simple energy meter.

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LIST OF ABBREVIATIONS

DC	Direct Current
AC	Alternating Current.
LCD	Liquid Crystal Display
IR	Infrared Receiver
IC	Integrated Circuit
LED	Light Emitting Diode
PCB	Printed Circuit Board

CHAPTER I

INTRODUCTION

1.1 Introduction

Microcontroller platform Arduino Based Integration of Energy Meter is very effecient & workable project. In this project we developed a energy meter which can sensing load current ,voltage & calculate the KWH & Bill.It is very suitable for industry or home. This project produces the design and building a system that gives a solution to the measurement of energy and helps the local customers to save the power in an efficient manner. ARDUINO as the heart of this project because it is very easy to write code in its IDE and there are huge numbers of open source library available in the internet which can be used according to the requirement.

1.2 Background Study

The power meters are one of important aspect in the smart grid concept [1]. They are the devices which measure electricity and also connecting different equipment over the electric grids. The concept that introduce the automation of measurements of electronic meters was called AMR (Automated Meter Reading). AMR is a concept that enables devices to be accessed remotely and collect the electronic data generated by the meter at consumer units. The data then transmitted from the meter to the electric company using radio frequency, telephone, power line or satellite communication [1]. A smart energy meter (SEM) is electronic device having energy meter chip for electric energy consumed measurement, protocols for data communication, security purposes, interface for data display and other function[2]. The difference of smart meter from traditional energy meter devices is by its communication ability. A smart meter should be able to record active power consumption and also other information of an electronic device, such as: voltage and current phasors, reactive power, maximum power demand, frequency, power factor and other information, in real time [1]. The Internet of Things (IoT) is defined by ITU and IERC as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things"

have identities, physical attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network [3]. Following the utilization of IoT, the smart meters needs to be developed with the intention of using device and communication technology to attain consumer satisfaction. This paper present a design of a smart energy meter, which provide accurate measurement of power consumption and display it to the consumer.

1.3 Objectives

The main objective of this system is to introduce a automated smart energy meter system with microcontroller technology. The supplementary objectives of this project are as follows:

- To Design & Construct of arduino Based Energy Meter.
- To Design & Implement of Load Voltage,Current ,Kwh & Bill Monitoring Sytem.
- To Design & Implemetn of Complete Energy Meter Solutions.

1.4 Project Organization

In this report, Chapter one covers introduction, background, objectives. Chapter two represents theory, description of the Arduino, Voltage Sensor,Current Sensor, LCD display and other components of this project. Chapter three describes the block diagram,circuit diagram & working principle of the project. In chapter four we have discussed result and discussion, cost estimation, future modification, conclusion.

CHAPTER II

THEORY OF THE PROJECT

2.1 Introduction

This chapter includes the total over view of the device. In this chapter we have followed-up the theory of Arduino Nano, LCD Display, Voltage Sensor,Current Sensor,Resistor, Capcitor, briefly describe of Microcontroller (ATMEGA 328P),and other components. Here we can know that the total system overview of the projects. And we will also know that how the equipment are working with each other.

2.2 Theory

We've developed the system that can handle this project perfectly. Our system has several voltage, and current sensors to measure the load voltaeg & Current. Based on those circumstances our system calculate the power of load. Our project based on arduino which is the a cimple & complete solution of energy meter.It also can provide stable output twenty four houres.

2.2.1 Arduino Nano

Arduino is an open-source electronicss prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

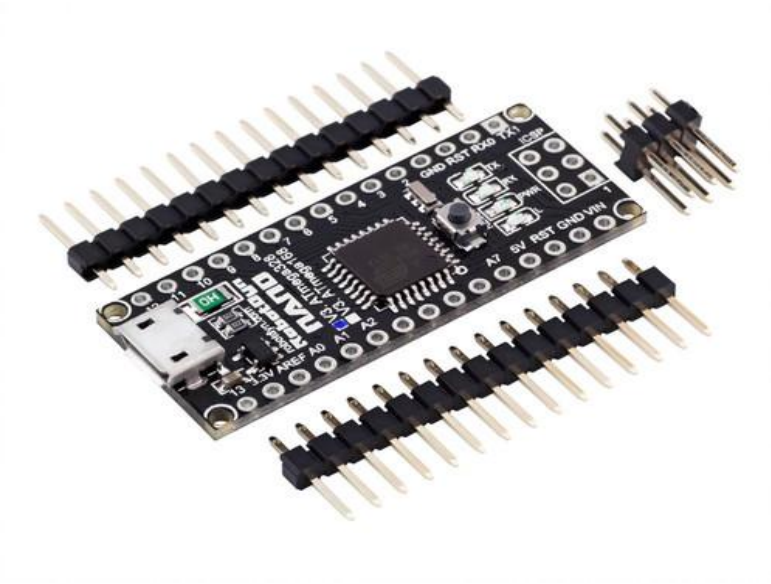


Figure 2.2.1.1 : Arduino Nano

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila/Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power.

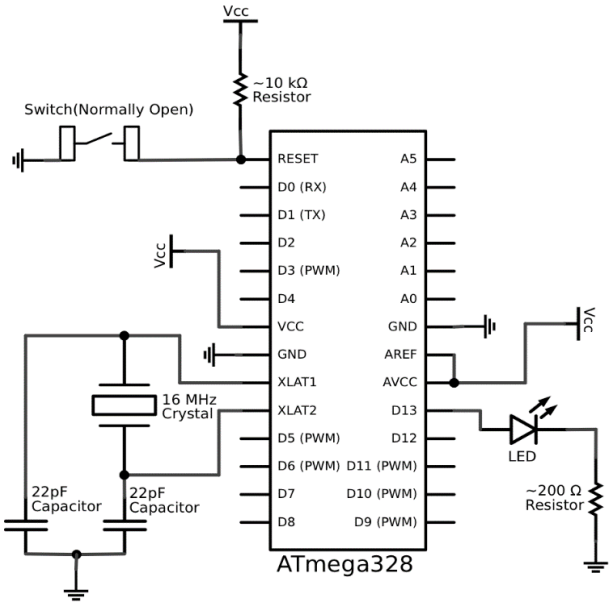


Figure 2.2.1.2 : Arduino Schematic Diagram

Nano's got the breadboard ability of the Boarduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, GND on one top, power and ground on the other). This new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.

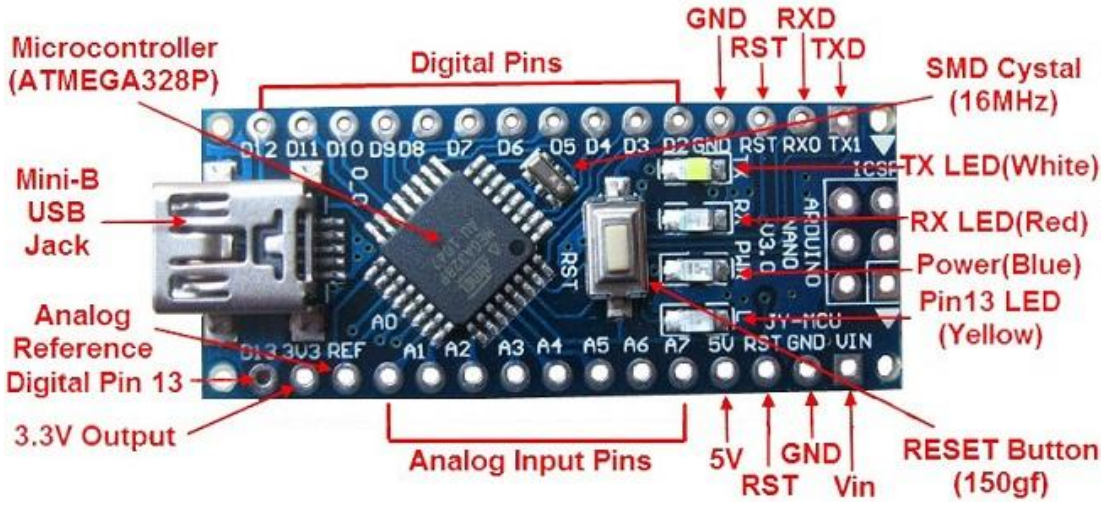


Figure 2.2.1.3 : Section of Arduino Nano

Specifications :

Microcontroller: Atmel ATmega328

Operating Voltage (logic level):5 V

Input Voltage (recommended):7-12 V

Input Voltage (limits):6-20 V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 8

DC Current per I/O Pin: 40 mA

Flash Memory: 32 KB (of which 2KB used by boot loader)

SRAM : 2 KB

EEPROM: 1 KB

Clock Speed: 16 MHz

Dimensions: 0.70" x 1.70"

Features :

• Automatic reset during program download

• Power OK blue LED

• Green (TX), red (RX) and orange (L) LED

• Auto sensing/switching power input

• Small mini-B USB for programming and serial monitor

• ICSP header for direct program download

• Standard 0.1 spacing DIP (Breadboard friendly)

• Manual reset switch

Microcontroller IC ATmega 328P:



Figure 2.2.1.4 : Microcontroller IC ATmega 328P

The high-performance Microchip Pico Power 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz balancing power consumption and processing speed.

Appendix

Code:

```
#include <SoftwareSerial.h>
 float count;
#include <Wire.h>
#include <LCD.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27 , 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
//LiquidCrystal_I2C lcd(0x3F , 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE);
int ref=219;
int href=50;
int data=0;
int volt=0;
int hz=0;
float bill = 0;
const int sensorIn = A3;
int mVperAmp = 66; // use 100 for 20A Module and 66 for 30A Module
double Voltage = 0;
double VRMS = 0;
double AmpsRMS = 0;
float watt=0;
float wattt=0.07;
float kwh = 0;
float pf  = 0.85;
void setup() {
  lcd.begin(16,2);
  lcd.clear();
Serial.begin(9600);
lcd.print("==ENERGY METER==");
```

```
delay(3000);
lcd.clear();
delay(50);
}
void loop()
{
float result;
  int readValue;             //value read from the sensor
  int maxValue = 0;          // store max value here
  int minValue = 1024;          // store min value here

   uint32_t start_time = millis();
   while((millis()-start_time) < 1000) //sample for 1 Sec
   {
      readValue = analogRead(sensorIn);
      // see if you have a new maxValue
      if (readValue > maxValue)
      {
         /*record the maximum sensor value*/
         maxValue = readValue;
      }
      if (readValue < minValue)
      {
         /*record the maximum sensor value*/
         minValue = readValue;
      }
   }
   // Subtract min from max
   result = ((maxValue - minValue) * 5.0)/1024.0;

 Voltage = result;
 VRMS =(Voltage/2.0) *0.707;
```

```
AmpsRMS = ((VRMS * 1000)/mVperAmp)-0.18;
  Serial.print("  Current=  ");
 Serial.print(AmpsRMS);
data=analogRead(A0);
delay(1000);
if ((data>300) && (data>450))
{
  volt=ref-2;
  hz=href-2;
}
if ((data>451) && (data>550))
{
  volt=ref-1;
  hz=href-1;
}
if ((data>551) && (data>600))
{
  volt=ref+1;
  hz=href+1;
}
if ((data>601) && (data>700))
{
  volt=ref+2;
  hz=href+2;
}
Serial.print("  Voltage= ");
Serial.print(volt);
watt=(AmpsRMS*volt)/1000;
Serial.print("  Watt= ");
Serial.println(watt);
if(AmpsRMS  < 0.75)
{
```

```
lcd.setCursor(0,0);
lcd.print(" V");
lcd.setCursor(0,1);
lcd.print(volt);
lcd.setCursor(5,0);
lcd.print("A");
lcd.setCursor(4,1);
lcd.print("bill");
lcd.setCursor(13,1);
lcd.print(00)
}
if(AmpsRMS > 0.75)
{
lcd.setCursor(0,0);
lcd.print(" V");
lcd.setCursor(4,1);
lcd.print(.40);
lcd.setCursor(9,0);
lcd.print(220);
lcd.setCursor(5,0);
lcd.print("kwh");
lcd.print(48);
delay(3000);
}
```

2.2.2 LCD Display:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs.

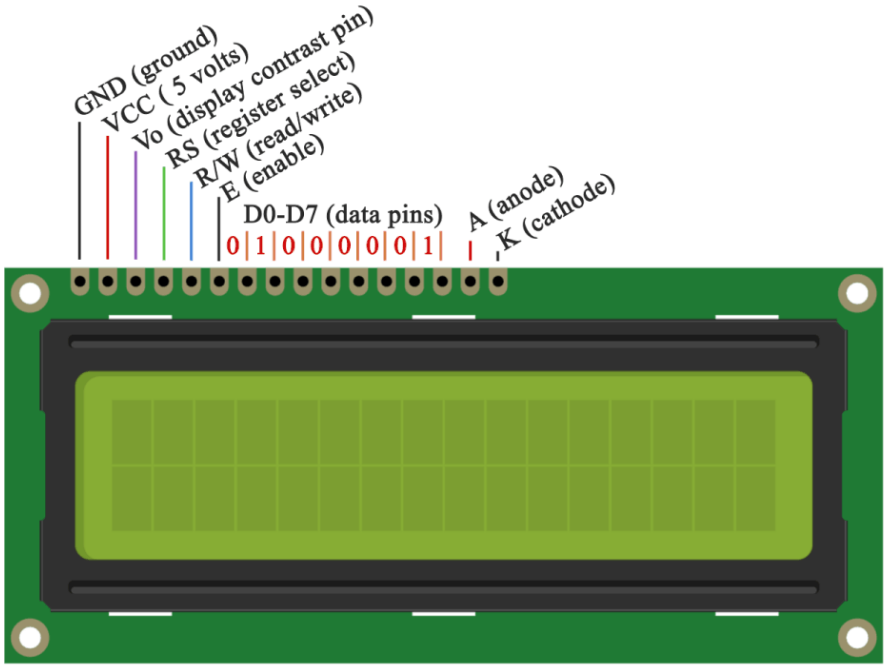


Figure 2.2.2.1: 16*2 LCD Display Schematic Diagram.

The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

Interface pin description

Pin no.	Symbol	External connection	Function
1	Vss	Power supply	Signal ground for LCM
2	V_{DD}		Power supply for logic for LCM
3	V_0		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7~10	DB0~DB3	MPU	Four low order bi-directional three-state data bus lines. Used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11~14	DB4~DB7	MPU	Four high order bi-directional three-state data bus lines. Used for data transfer between the MPU
15	LED+	LED BKL power supply	Power supply for BKL
16	LED-		Power supply for BKL

Table 2.2.2.1:LCD Display Pin Description

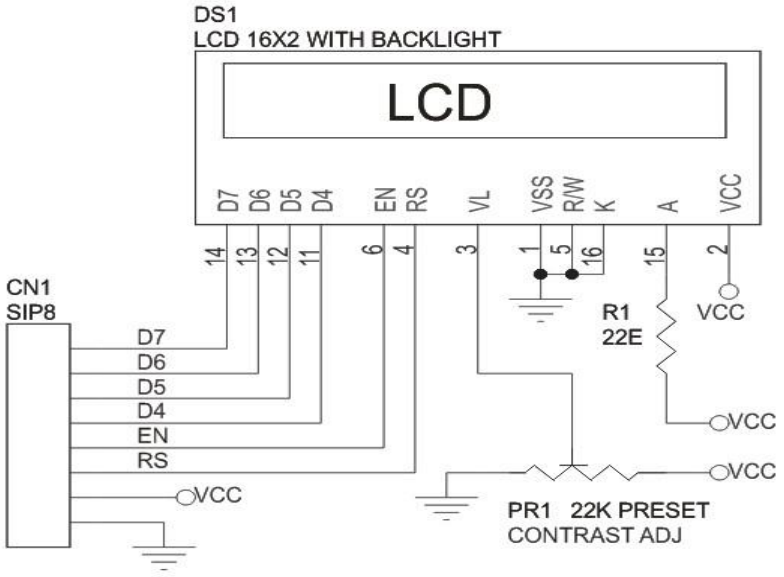


Figure 2.2.2.2 16*2 LCD Display Schematic Diagram.

Features of LCD Display

1. 5 x 8 dots with cursor
2. Built-in controller (KS 0066 or Equivalent) + 5V power supply (Also available for + 3V) 1/16 duty cycle
3. B/L to be driven by pin 1, pin 2 or pin 15, pin 16 or A.K (LED) N.V. optional for + 3V power supply.

2.2.3 12V DC Power supply (Rectifier)

A bridge rectifier circuit is a common part of the electronic power supplies. Many electronic circuits require rectified DC power supply for powering the various electronic basic components from available AC mains supply. We can find this rectifier in a wide variety of electronic AC power devices like home appliances, motor controllers, modulation process, welding applications, etc.

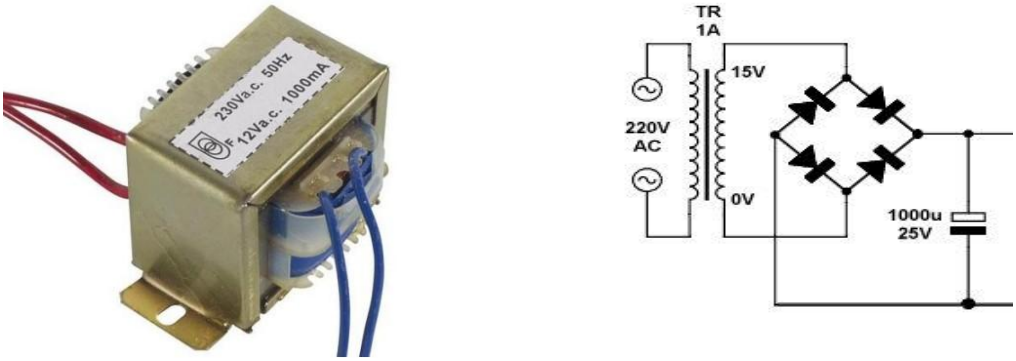


Fig: 2.2.2.1: 220/12V rectifier

The bridge rectifier circuit diagram consists of various stages of devices like transformer, Diode Bridge, filtering and regulators. The first stage of the circuit is a transformer which is a step-down type that changes the amplitude of the input voltage. Most of the electronic projects uses 230/12V transformer to step-down the AC mains 230V to 12V AC supply. Next stage is a diode-bridge rectifier which uses four or more diodes depending on the type of bridge rectifier. Choosing a particular diode or any other switching device for a corresponding rectifier needs some considerations of the device like Peak Inverse Voltage (PIV), forward current If, voltage ratings, etc. It is responsible for producing unidirectional or DC current at the load by conducting a set of diodes for every half cycle of the input signal.

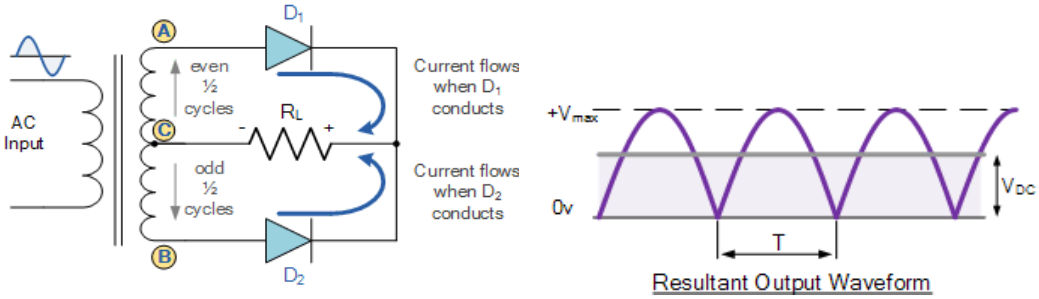


Fig: 2.2.3.2: Output Waveforms of 220V/12V rectifier

2.2.4 Voltage Sensor:

A voltage sensor is a sensor is used to calculate and monitor the amount of voltage in an object. Voltage sensors can determine both the AC voltage or DC voltage level. The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc.

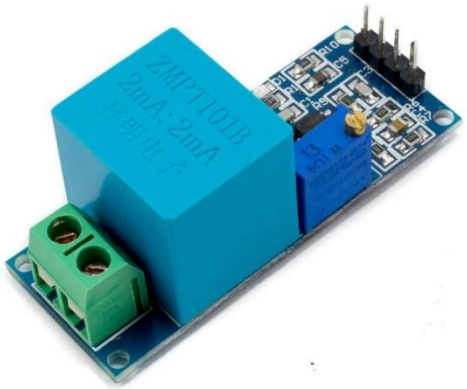


Figure 2.2.4.1: Voltage Sensor

Description

Single-phase AC active output voltage mutual inductance module equipped with ZMPT101B series of high-precision voltage transformer and high-precision op amp current, easy to 250v within the AC power signal acquisition.

Features

- Measure within 250V AC
- Rated input current: 2mA
- Onboard micro-precision voltage transformer
- Analog output corresponding quantity can be adjusted
- Good consistency for voltage and power measurement
- Active output single-phase AC voltage sensor module

Specification

- Output Signal: Analog 0 - 5V
- Size: 49.5 mm x 19.4 mm
- Operating temperature: 40'C ~ + 70' C

2.2.5 Current Sensor:

A current sensor is a device that detects electric current in a wire, and generates a signal proportional to that current. The generated signal could be analog voltage or current or even a digital output.

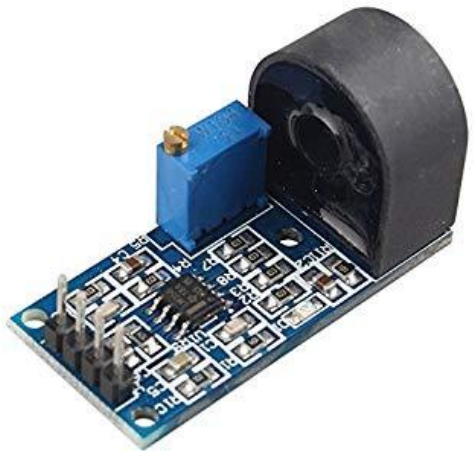


Figure 2.2.5.1: Current Sensor

Features:

1. Onboard precision micro current transformer
2. High precision op-amp circuit board, do accurate sampling for the signal and appropriate compensation, and other functions
3. The module can measure within 5A current communication, corresponding to output analog quantity can be adjusted
4. PCB board size: 38 (mm) x18.5 (mm)

Description:

This module is ideally suited to providing an accurate AC current measurement up to 5 Amps. A proportional voltage signal will be provided on the Output pin, at a 1000:1 transormation ratio. This provides a simple and effective way of monitoring current in your project.

Please do not hesitate to contact us if you require further information regarding the module's operation.

Pin Description:

GND	0V
OUT	Analog output
VCC	3 - 5V

CHAPTER III

DESIGN & FABRICATION

3.1 Introduction

In this chapter fully cover with discuss design and fabrication of this project. Here we will discuss about developed block diagram and briefly describe about the circuit description and also learn about working principle. Total project flow chart is also available in this chapter.

3.2 Block Diagram

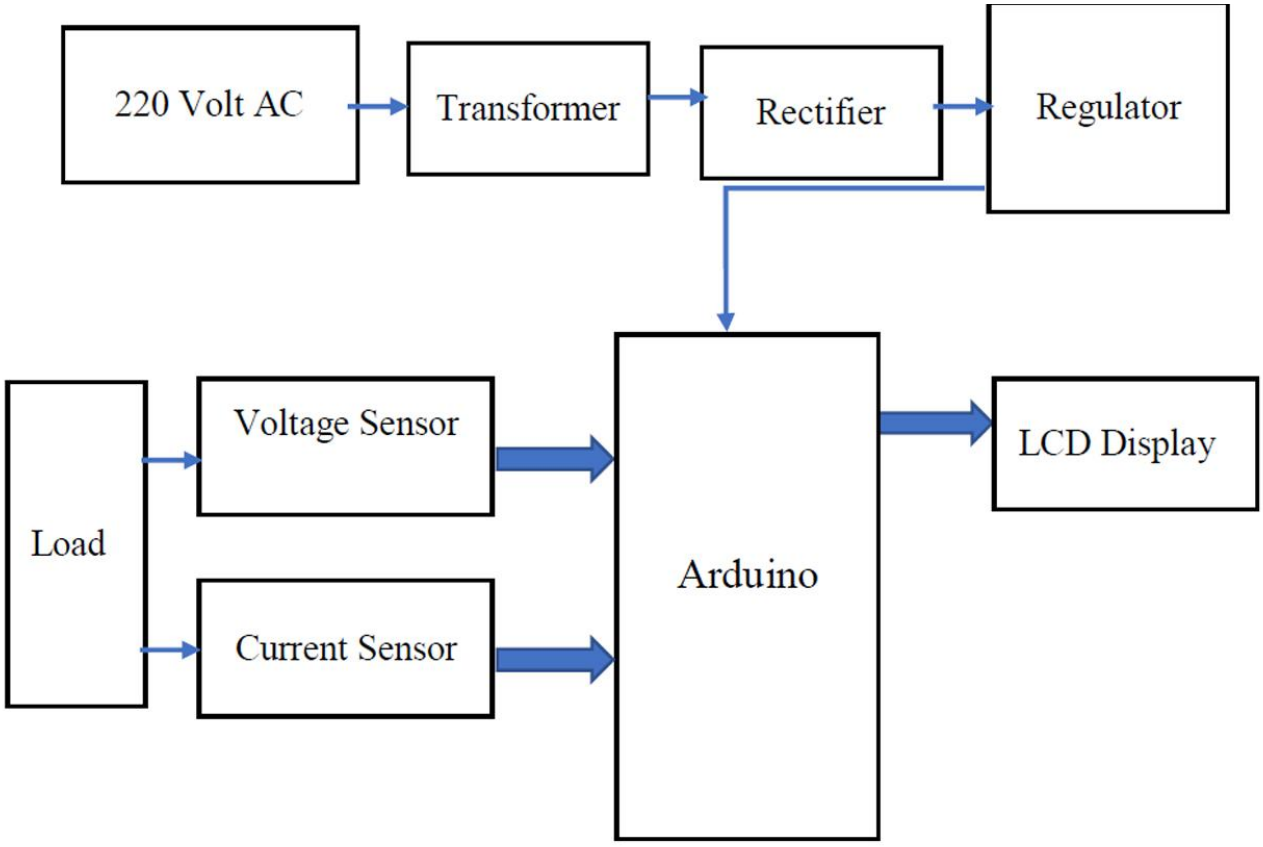


Fig: 3.2.2.1: Block diagram of project

Here's the block diagram of our Arduino Based Energy Meter. We can clearly describe the working process through this block diagram. Firstly we have 220volt AC power sources to supply electricity. One is the Transformer then rectifier,Regulator which is the complete DC power suystem for our project. Our control system continuously monitors the voltage and the current of load which is the showing in LCD Display. Voltage sensor & current sensor sense the voltage & Current of load & this signal send the arduino .arduino is the main brain of our project,Arduino calculate the KWH of power consumption .All processes, voltages, current and current,kwh & bill is shown in a LCD display.

3.3 Circuit Description

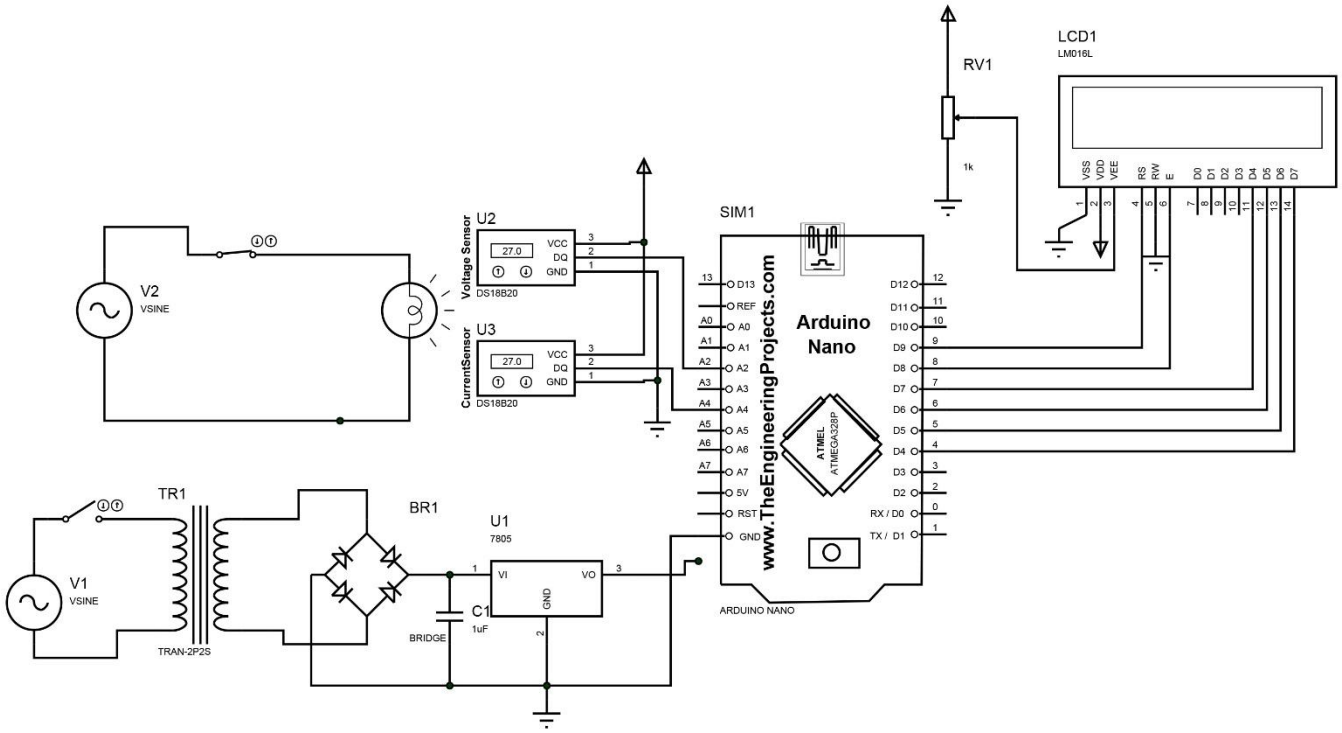


Fig: 3.3.3.2: Circuit diagram of the Project

In our circuit, we've used an Arduino Nano as the main controller, one voltage sensors to measure the load voltages.A current sensor is used to measure the load current. A voltage stabilizer is also used to provide a stable voltage to the loads.The current sensor & voltage sensor continuously measures the load current and voltages shows it to the LCD display.here we used a step down transformer which can convert AC220 voltage to AC 6 voltaeg.we used

this system bridge rectifier which convert AC to DC voltage & a capacitor use for produce pure DC voltage.Arduino,LCD display,voltage sensor& current sensor input voltage is 5 so we have use here a voltage regulator IC which can supply continuasly fixed voltage.

3.4 Working Principle

The picture above is the actual demo project we've made. Now let's take a look at the step by step working process.

After powering up everything these one load ON & Display showing this load voltage current watt kwh & Bill.

Voltage sensor & Current sensor continuously reading voltage & current which is the send Arduino.

Arduino calculate load voltage current watt kwh & bill.

LCD display showing all-time total process of project. & whole system power up Switch Mode Power Supply(SMPS).

3.5 Image of the Project

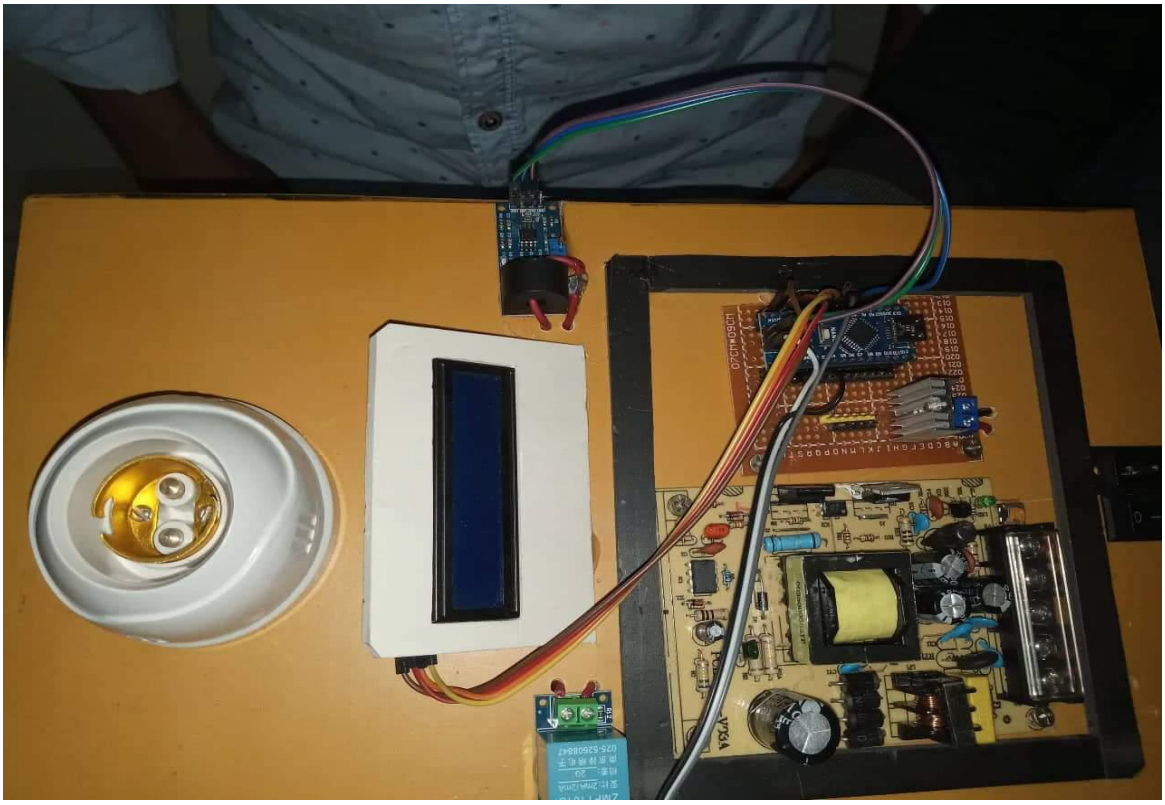


Fig: 3.5.5.1: Real image of the project

3.6 Flow Chart

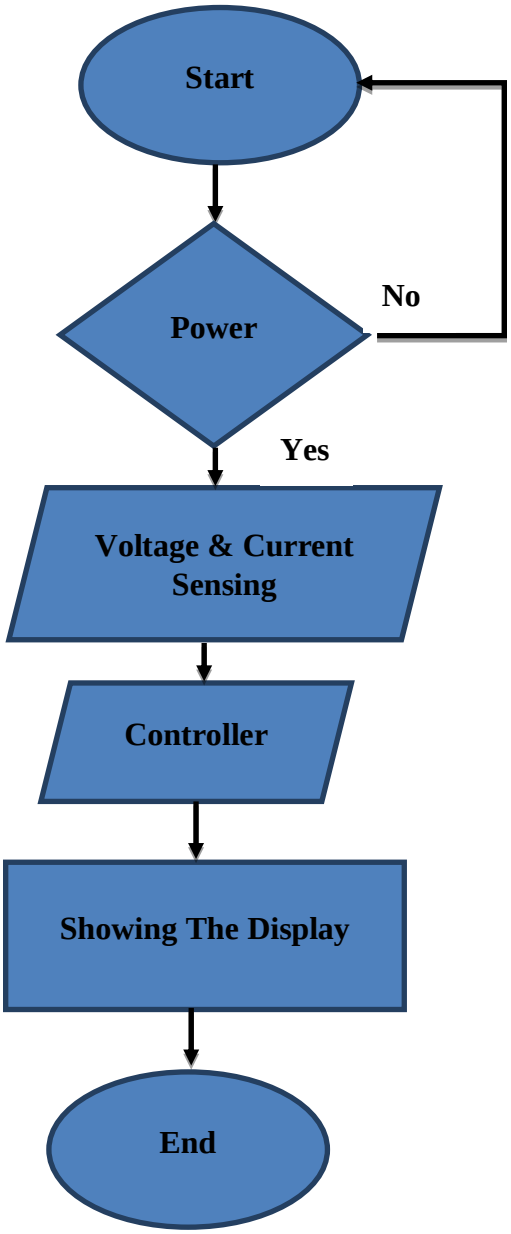


Fig: 3.7.7.1: Flow chart of the project

In this flowchart we can easily determine the working process of our system. Starting with some control initializations our control system reads/measures the voltage and current of load. The voltage and current is shown & updated every second in a LCD display. The control system calculate the kwh & bill continuously.

3.7 Used Materials

1. Microcontroller (Arduino Nano) - 1 pcs
2. LCD -1 pcs
3. Transformer (6V) - 1 pcs
4. Switch - 1 pcs
5. LED light - 1 pcs
6. Connector - 2 pcs
7. Current Sensor - 1 pcs
8. Voltage Sensor - 1 pcs
9. Wires - As needed

3.8 Conclusion

In this chapter we have discussed the block diagram,circuit discription, working principle, flow chart also show the real image of the project and others. In the later part of this paper we discussed the result & discussion of the project to make the concept clear to anyone.

Chapter IV

RESULT & DISCUSSION

4.1 Introduction

This chapter contains the results obtained and discussion about the project. We have also covered discussions about advantages, disadvantages and limitation of current version of the protection system.

4.2 Result

- Voltage Current watt showing in LCD display.
- Kwh & Bill can be continuously monitoring in LCD display.

4.3 Advantags of Smart Grid

- Can be continuously monitoring Voltage, Current, watt, kwh & Bill.
- Cost Effective.
- Portable & Easy to install.
- High Accuracy.

4.4 Disadvantages of Smart Grid

- In this project can't workable for together many load.
- Our developed project can't monitoring Remotely.

4.5 Discussion

By implementing above systems there are various benefits.

- By continuously monitoring the status of load, we can control the selection of power sources.
- Conservation of labor: Since the systems are automatic, they do not require continuous monitoring by labor.
- The design is low cost, small size, robust and highly versatile.
- This system use microcontroller which make it more convenient than conventional system.
- The main advantage is that the system's action can be changed according to the situation (high/Low power consumption of load).

4.6 Cost Estimation

Table:4.1: Cost Estimation

SI	Particulars	Specification	Qty.	Unit Price	Total Price
1	Arduino Nano	ATmega328p	1	350	350
4	LCD Display	16x4	2	250	500
5	Transformer	230V/15V, 3Amp	1	250	250
6	wire	As per need	20ft	20	400
7	Capacitor	1000uf, 25V	1	10	10
8	Voltage Sensor	220 Volt 10 A	1	280	280
9	Current Sensor	220 V 10 A	1	350	350
10	Vero Board		1	40	40
11	Resistor	Various	20	1	20
12	Soldering cost				30
13	Others				100
				Total	**2,330**

4.7 Applications

In this project can be used Home,industry as a complete solution of energy meter.

4.8 Conclusion

A energy meter is an simple complete solution of power sectot as a energy meter.this sytem work very well.finally we have successfully completed this system accourding of our design.in future can be more develope this syetm.

Chapter V

CONCLUSION

5.1 Conclusion

This project proposed new approach of energy meter monitoring system by using Arduino Nano as the users in the purpose of the flexibility of the customers to monitor their current bill or power consumptions usage .The results showed that the system works successfully. Future research is controlling the energy meter, meaning instead of just monitoring the meter, usage, power consumption, controlling them will be one step further, so that the users can even control their bill, usage, power consumptions by themselves remotely from their mobile phones.

5.2 Future Work

At present we have made the Arduino based energy meter.in future development in this project can be added more sensor IoT Control & Monitoring System.

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